dismissed as unimportant, and the important ones more readily isolated, if we could answer the how much?, or how many are there?, questions, in relation to the how much is needed for...?, or how many matter to...? ones.

The Authors give little space to the few attempts that have been made to develop mathematical models of the rhizosphere: for example, the pioneering work of J. Newman & H. Watson on the distribution of the microbial population across the rhizosphere is hardly mentioned. Many of their assumptions may be wrong, but the very existence of their model challenges others to get better data and improve their concepts. This is the weakness of an otherwise thoroughly worthy book.

The quality of the print, plates, and diagrams, is good; but at a price of US $127 of 288 pages they certainly should be!

PETER H. NYE, *Reader in Soil Science*
University Soil Science Laboratory
Agricultural Science Building
Parks Road
Oxford OX1 3PF, England, UK.

Energy and Resource Quality: The Ecology of the Economic Process, by CHARLES A. S. HALL, CUTLER J. CLEVELAND, ROBERT KAUFMANN & nine contributors. Wiley–Interscience, New York–Chichester–Brisbane–Toronto–Singapore: xxi + 577 pp., illustr., tables, 28.5 x 22 x 3 cm, hard cover, 1986.

Let us review this book—which is a major attempt to reunite, to some degree, ecology and economics from an energy–resource interaction viewpoint—by dealing with four main questions: (i) What is economics? (ii) What is energy? (iii) What are natural resources? (iv) How are natural resources, energy, and economics, interrelated?

(i) *Economics:*—The book indicates that human economic systems are considered from the same energy perspective as in ecosystem biology (therefore the subtitle of the book is appropriate: 'the ecology of the economic process'). The two systems are constrained by the same physical laws, and in addition are both connected to two main energy-sources which are the Sun and solar-derived fossil fuels. Basically, the Authors try to understand economics (and US prosperity) from a thermodynamical perspective (namely the ability to empower human labour with abundant high-quality energy) rather than from the utility-based perspective of neoclassical economics (involving subjective human preferences). Thus, economics is defined as the discipline that is concerned with the transformation of natural resources to goods and services.

(ii) *Energy:*—Energy is a resource which is used in Nature and human society. It has physical characteristics that constrain human activities, though as a resource it has different qualities. So what energy means will depend on the frame of reference of the observer. In this book, energy is considered as the capacity to do work, the latter being defined according to physics (namely as a force moving a material body over a distance). Energy is measured in heat equivalents (kcal). Various forms of energy are essential, on one hand indicating the many different ways in which energy occurs—heat energy, mechanical energy (potential and kinetic energy), electrical energy, and so on—on the other hand expressing the various qualities of energy according to a hierarchy (a kcal of hydroelectricity can produce more output than a kcal of coal when converted into electricity). In short, one form of energy can be changed into another form of energy: the same total quantity will remain (as heat equivalents—First Law) but not with the same quality (some being altered—Second Law). Finally, an energy transformation process is submitted to a less than 100% efficiency ratio (useful work delivered to total energy input, both being measured in the same energy units). As for the concept of entropy (as a measure of the randomness of the system), it is introduced in the sense of N. Georgescu-Roegen and H.T. Odum who maintain that a flow of low-entropy energy is necessary to maintain any organized structure.

(iii) *Natural resources:*—The natural resources are the raw materials that are extracted, refined, processed, and finally upgraded, into useful goods and services. Here a wise though not crystal-clear distinction is made: the transformation of natural resources into economic outputs has been called *economic work* (physical units?), whereas all energies that humans control and direct for their own purposes have been called *economic* energies (in physical units). Thus—if the Reviewer has understood—'natural resources' is a generic term whereas economic energies designate those natural resources which are already in the market place. Consequently, a given natural resource is made available to society by means of economic energies (i.e. of natural resources already in the market-place). The quality of such a resource is defined in terms of the economic energy that is needed to make it available for further transformation into goods and services. A quality-index corresponding to this energy-opportunity cost has been built and used throughout the book (*see* iv).

(iv) *How are economics, energy, and natural resources, interrelated?*—This book is an analysis of the economic process from an energy perspective, in theory and in practice, using data mainly on the United States (since about 1850). The subject is complex and controversial, but the coverage is large, balanced, and sober enough to override rhetorical exchanges between environmentalists and economists. Yet, it is true that the biophysical economic perspective comes from outsiders, if we except leading economists such as N. Georgescu-Roegen and H.E. Daly. However, it is also true that, from a standard economic perspective, economics is not concerned at all with this kind of analysis. The physical interdependence between natural resources and economic factors of production has existed ever since humans began to modify their natural environment. However, it took on greater significance when the economies shifted their dependence from renewable to non-renewable fuel sources, and made energy the limiting factor in industrialized processes.

This, in short, is the argument of the book, which is therefore an attempt to integrate the analysis of energy-resource systems (the US one in particular) with that of economic processes, with due attention to energy-resources' quality; that is, to the amount of energy required to locate, extract, and refine, fuels to a socially useful state. This aspect of resource quality (e.g. fuel) is measured by a special ratio, namely EROI, for energy return on investment, which is the ratio of the gross amount of fuel extracted in the energy transformation process to the economic energy required to make that fuel available to society. EROI—together with the related ideas of economic work, natural resource, and economic energies—is used as the conceptual passageway through the pertinent chapters of the book.

To sum up, natural resources do not determine what humans can and cannot do, though the *quality* of these resources affects the level of the economic output. *Ceteris paribus*, economies with access to resources having higher EROI can do more economic work than those with lower

EROI, which reflects thermodynamic constraints. This index has been declining since 1940 (for metals) and since the 'sixties for fuels and some other resources.

This is a very penetrating, comprehensive, and even flashing book, though it may not be really decisive in interlocking economics and ecology—but is this possible without new *economic concepts*? Meanwhile the book deals with the 'ecology' of the economic process—not with the economic process itself.

GONZAGUE PILLET, *Research Economist*
Centre for Human Ecology
and Environmental Sciences
University of Geneva
P.O. Box 266
CH-1227 Carouge-Geneva,
Switzerland.

Down to Business: Multinational Corporations, the Environment, and Development, by CHARLES S. PEARSON. World Resources Institute, 1735 New York Avenue NW, Washington, DC 20006, USA: vii + 107 pp., 22.5 x 15.2 x 0.7 cm, stiff paper cover, US $3.50, 1985.

Ever since the 1972 Stockholm Conference on the Human Environment, research and other endeavours have expanded to find ways of satisfying the growing demand for ever-improving living standards by a globally increasing population while, at the same time, mitigating the adverse impact of human activities on Nature. Among such endeavours was the setting up of the World Resources Institute in Washington, DC, in 1982. Its purpose is to assist governments, international organizations, and private enterprise—including multinational corporations (MNCs)—to promote sustainable development particularly in Third World countries. The Institute has sponsored several research projects, one of which was the Private Sector Initiatives Project, which was launched in June 1983. Its findings were discussed at a conference, an outcome of which was the book, now under review, written by Charles S. Pearson, Professor of International Economics at the Johns Hopkins University School of Advanced International Studies, and Director of the Private Sector Initiatives Project.

The papers presented at the conference addressed a variety of development problems in widely differing Third World countries hosting MNCs. Thus, in Nigeria, one of the main problems is the pollution of the coast and even the ocean by the oil industry; in Indonesia, it is the felling of rain-forests which results in denuded land that is either left to erode into wasteland or, at best, becomes settled by landless squatters practising—for as long as it lasts—slash-and-burn agriculture among the stumps and leftovers of the timber-exporting corporation; in Mexico a major danger is the importation and misuse of pesticides, etc.

However different the types of business carried on by MNCs, and however different the countries and areas where they operate, a common feature is the financial and technological power of the MNCs coupled with their endeavour to obtain short-term economic returns even at the expense of long-term environmental damage. So the object of the Conference on MNCs, the Environment, and Development, was to consider ways that would enable MNCs to remain profitable while preventing the worst effects of development such as what Maurice Strong described as 'the pollution problem moving South' (p. 2).

Because of poverty and backwardness, Third World countries have often been slow to introduce environmental protection laws, and often have neither the expertise nor the money to finance expensive purification systems. Moreover, stringent antipollution measures might drive away MNCs that provide the local governments with much-needed foreign exchange (from taxes and royalties) and much-needed employment (for poor and ever-growing populations). This is particularly the case with the more polluting industries which have been relocated from their home countries, where antipollution laws are both stringent and enforced, to 'pollution havens'.

Now pressure is growing for the MNCs to face up to their responsibilities. Thus UNEP has a section producing an International Register of Potentially Toxic Chemicals, and requires their detailed labelling. Support has also come from the United States Government, which in 1979 prevented a Colorado company from sending its hazardous mining-wastes for disposal in Sierra Leone, and, in a similar case, the shipment of wastes to Haiti (p. 56). Some United States agencies sponsoring development, such as the Export–Import Bank and the Overseas Investment Corporation, now ask for estimates of environmental impact of the projects which they finance (pp. 64–5). They would hesitate to finance projects that are potentially adverse to the environment, as was the case earlier with 37% of those sponsored by the World Bank (footnote 136, p. 106).

Host countries have also become more aware of environmental degradation than they were before, and are introducing appropriate legislation (Indonesia in 1978, South Korea in 1980, Brazil in 1981, Mexico in 1982, Turkey in 1983, and China in 1984), though enforcement is still apt to be lax owing to ignorance and/or corruption. Host countries are also becoming aware of the need for anticipatory impact and cost–benefit studies in their planning, and require, from MNCs, technologically advanced purification systems that are conducive to technology transfer in general. Protection measures can also benefit the MNCs themselves, as in the case of reafforestation which will extend the time-span of logging operations, and the prevention of health hazards which will improve the labour productivity of workers, etc.

The book—which, incidentally, is very well laid out—ends on an optimistic note. Fruitful collaboration on equal terms may bring about a possibly slower but far more sustainable development, and eventually benefit both the MNCs and their host countries.

ELISABETH KOUTAISSOFF
49 Granville Court
Cheney Lane
Oxford OX3 OHS
England, UK.

Mammal Society Series. Anthony Nelson Ltd, P.O. Box 9, Oswestry, Shropshire, England, UK: card covers, £2 each, 1986. **Shrews,** by SARA CHURCHFIELD: 20 pp., 7 plates, 8 figs, 20.4 x 15.8 x 0.2 cm. **Moles,** by DAVID STONE: 20 pp., 11 plates, 7 figs, 20.4 x 15.8 x 0.2 cm. **Mink,** by JOHN BIRKS: 24 pp., 9 plates, 8 figs, table, 20.4 x 15.8 x 0.3 cm.

These three excellent booklets comprise the second batch published by the Mammal Society, fulfilling well their objective of providing factual information about the species covered, with good illustrations, available at a low price, and written in easily-understood terms. Each of the Authors has carried out research in the field on the particular species involved. The books are strongly recommended to those who want to learn more about mammals.

J.F.D. FRAZER, *Chairman*
Environment & Wildlife Ltd
Warren Farm, Boxley
Maidstone, Kent, England, UK.